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PATENT COOPERATION TREATY

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From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing *(day/month/year)*	16.08.2004
Applicant's or agent's file reference	IMPORTANT NOTIFICATION
~~663876~~ MA 2521-01WO	

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/JP 03/09224 ✓	22.07.2003 ✓	23.07.2002 ✓

Applicant
MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD. et al. ✓

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

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ATTACHMENT G

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 663876 ✓	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/JP 03/09224 ✓	International filing date *(day/month/year)* 22.07.2003 ✓	Priority date *(day/month/year)* 23.07.2002 ✓
International Patent Classification (IPC) or both national classification and IPC H05K13/08		
Applicant MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD. et al. ✓		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 9 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ - Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09.02.2004	16.08.2004
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Debre, A Telephone No. +49 89 2399-2347

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/JP 03/09224 ✓

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-51 ✓ as originally filed ✓

Claims, Numbers

1-36 ✓ received on 17.06.2004 with letter of 17.06.2004 ✓

Drawings, Sheets

1/19-19/19 ✓ as originally filed ✓

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-36 ✓
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-36 ✓
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-36 ✓
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. US-A-6 289 582 is regarded as the closest prior art document as regards the subject-matter of claim 1. It describes a component mounting order optimization method in which the component supply parts are arranged in accordance with the mounting sequence of the components to be mounted on the circuit board.

   The subject-matter of claim 1 differs from what is described in this document by the method steps of :
   representing the mounting point in a three dimensional space which is given that a Z-number showing a location of each component supply part is expressed by a Z-axis and a plane of the circuit board is expressed by the X and y-axes; and
   determining an arrangement of the component supply parts and a component mounting order on the circuit board so that a component mounting path connecting the mounting points in the three dimensional space becomes the shortest.

   The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

   The problem to be solved by the present invention may be regarded as to provide a component mounting order optimization method whereby the mounting time can be shortened as compared with the conventional art.

   The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

   The other documents cited in the search report belong to the technological background. None of these documents discloses or suggests the above mentioned new method steps for optimizing a component mounting order.

2. Independent claims 10, 19, and 28 relate to a component mounting order optimization programm, a computer readable recording medium storing such program stored, and a component mounting apparatus comprising an optimizing part that carries out the optimizing method. In all of these independent claims, the optimization method as defined in claim 1 is implemented in corresponding

features. These claims, therefore, meet the requirements of novelty and inventive step as well.

3. Claims 2 to 9, 11 to 18, 20 to 27 and 29 to 36 are dependent claims and as such also meet the requirements of the PCT with respect to novelty and inventive step.

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DT15 Rec'd PCT/PTO 07 JAN 2005

New claims 1 to 36

1. A component mounting order optimization method executed before carrying out a component mounting operation in which a component is held from one component supply part (103a) disposed at a component holding position (171) among a plurality of component supply parts (103a) arranged in parallel and arranged movably for supplying components, is transferred to a component mounting position (172), and is mounted to a mounting point (173) on a circuit board (2) disposed at the component mounting position by moving in X-axis and Y-axis directions, the method comprising:
representing the mounting point (173) in a three dimensional space which is given that a Z-number showing a location of each component supply part (103a) is expressed by a Z-axis and a plane of the circuit board (2) is expressed by the X and Y-axes; and
determining an arrangement of the component supply parts (103a) and a component mounting order on the circuit board (2) so that a component mounting path connecting the mounting points (173) in the three dimensional space becomes the shortest.

2. The component mounting order optimization method according to Claim 1, wherein the determining operation has:
optimizing the arrangement of the component supply parts (103a) with position information of the mounting points (173) taken into account; and then
optimizing the component mounting path in the three dimensional space so that the mounting path becomes the shortest under the optimized arrangement of the component supply parts (103a).

3. The component mounting order optimization method according to Claim 2, further comprising:
after the optimization of the component mounting path, rearranging the component supply parts (103a); optimizing the component mounting path again under the rearrangement of the component supply parts (103a); and selecting a component mounting path having a shorter mounting path length through comparison between before and after the rearrangement of the component supply parts (103a).

4. The component mounting order optimization method according Claim 2, wherein the optimization of the arrangement of the component supply parts (103a) is carried out by temporarily arranging the component supply parts (103a) and correcting the temporary arrangement before optimizing the component mounting path.

5. The component mounting order optimization method according to Claim 4, wherein the temporary arrangement in optimizing the arrangement of the component supply parts (103a) is executed by obtaining a product of variances ($\sigma 1$, $\sigma 2$) for each of X and Y-coordinate values and Z-values showing locations of the component supply parts (103a) in terms of the mounting points (173) of the circuit board (2) while the Z-value is changed, and then obtaining the arrangement of the component supply parts (103a) which makes the variance product ($\sigma 1$, $\sigma 2$) smaller.

6. The component mounting order optimization method according to Claim 5, wherein, the arrangement which makes the variance product ($\sigma 1$, $\sigma 2$) smaller is obtained by executing:
a first process of obtaining a first variance product for a first arrangement of the component supply parts (103a);
a second process of obtaining a second variance product for a second arrangement different from the first arrangement; and
a third process of comparing the first variance product and the second variance product with each other and setting the smaller one as a new first variance product,
thereby obtaining a much smaller new first variance product by repeating the second process and the third process subsequently.

7. The component mounting order optimization method according to Claim 4, wherein, for correcting the temporary arrangement in optimizing the arrangement of the component supply parts (103a), after the component supply parts (103a) are temporarily arranged by obtaining the smaller variance product ($\sigma 1$, $\sigma 2$), the location of a second component supply part (103a-2) is changed on a basis of a distance between a reference mounting position (178) on the circuit board (2) where the component supplied from a first component supply part (103a-1) adjacent to the component holding position (171) is to be mounted and an object mounting position (179) on the circuit board (2) where the component supplied from the second component supply part (103a-2) other than the first component supply part (103a-1) is to be mounted, thereby further optimizing the arrangement of the component supply parts (103a).

8. The component mounting order optimization method according Claim 7, wherein the changing of the location of the second component supply part (103a-2) comprises:
obtaining each of the distances while the second component supply part (103a-2) is sequentially changed; and

arranging the second component supply part (103a-2) which makes the distance shortest adjacent to the first component supply part (103a-1).

9. The component mounting order optimization method according to Claim 2, wherein the component mounting path is optimized by selecting two mounting paths for connecting two mounting points (173) among mounting paths, recombining the two mounting paths, and selecting the path having a shorter mounting path length through comparison between before and after the recombination, thereby executing the optimization.

10. A component mounting order optimization program for making a computer execute a component mounting order optimization method in a component mounting operation in which a component is held from one component supply part (103a) disposed at a component holding position (171) among a plurality of component supply parts (103a) arranged in parallel and movable for supplying components, is transferred to a component mounting position (172), and is mounted to a mounting point (173) on a circuit board (2) disposed at the component mounting position (172) by moving in X-axis and Y-axis directions, the program comprising:
a procedure of representing the mounting point (173) in a three dimensional space which is given that a Z-number showing a location of each component supply part (103a) is expressed by a Z-axis and a plane of the circuit board (2) is expressed by the X and Y-axes; and
a procedure of determining an arrangement of the component supply parts (103a) and a component mounting order on the circuit board (2) so that a component mounting path connecting the mounting points (173) in the three dimensional space becomes the shortest.

11. The component mounting order optimization program according to Claim 10, wherein the procedure of determination has:
a procedure of optimizing the arrangement of the component supply parts (103a) with position information of the mounting points (173) taken into account; and then
a procedure of optimizing the component mounting path in the three dimensional space so that the mounting path becomes the shortest under the optimized arrangement of the component supply parts (103a).

12. The component mounting order optimization program according to Claim 11, further comprising:

after the optimization of the component mounting path, a procedure of rearranging the component supply parts (103a); a procedure of optimizing the component mounting path again under the rearrangement of the component supply parts (103a); and a procedure of selecting a component mounting path having a shorter mounting path length through comparison between before and after the rearrangement of the component supply parts (103a).

13. The component mounting order optimization program according to Claim 11, wherein the optimizing procedure for the arrangement of the component supply parts (103a) includes a procedure of temporarily arranging the component supply parts (103a) and a procedure of correcting the temporary arrangement before the optimizing procedure for the component mounting path.

14. The component mounting order optimization program according to Claim 13, wherein the temporary arrangement procedure in the optimizing procedure for the arrangement of the component supply parts (103a) includes a procedure of obtaining a product of variances ($\sigma 1$, $\sigma 2$) of each of X and Y-coordinate values and Z-values showing locations of the component supply parts (103a) while the Z-value is changed in terms of the mounting points (173) of the circuit board (2), and a procedure of obtaining the arrangement of the component supply parts (103a) which makes the variance product ($\sigma 1$, $\sigma 2$) smaller.

15. The component mounting order optimization program according to Claim 14, wherein the arrangement procedure of making the variance product ($\sigma 1$, $\sigma 2$) smaller includes:
a first procedure of obtaining a first variance product for a first arrangement of the component supply parts (103a);
a second procedure of obtaining a second variance product for a second arrangement different from the first arrangement;
a third procedure of comparing the first variance product and the second variance product with each other and setting the smaller one as a new first variance product; and
a procedure of obtaining a much smaller new first variance product by repeating the second procedure and the third procedure subsequently.

16. The component mounting order optimization program according to Claim 13, wherein the correcting procedure for the temporary arrangement in optimizing the arrangement of the component supply parts (103a) includes, after the component supply parts (103a) are temporarily arranged by obtaining the smaller variance product, a procedure

of changing the location of a second component supply part (103a-2) on a basis of a distance between a reference mounting position (178) on the circuit board (2) where the component supplied from a first component supply part (103a-1) adjacent to the component holding position is to be mounted and an object mounting position (179) on the circuit board (2) where the component supplied from the second component supply part (103a-2) other than the first component supply part (103a-1) is to be mounted, thereby further optimizing the arrangement of the component supply parts (103a).

17. The component mounting order optimization program according to Claim 16, wherein the procedure of changing the location of the second component supply part (103a-2) includes a procedure of obtaining each of the distances while the second component supply (103a-2) part is sequentially changed and arranging the second component supply part (103a-2) which makes the distance shortest to be adjacent to the first component supply part (103a-1).

18. The component mounting order optimization program according to Claim 11, wherein the optimizing procedure for the component mounting path includes a procedure of selecting two among mounting paths for connecting two mounting points (173), recombining the two mounting paths, and selecting the path having a shorter mounting path length through comparison between before and after the recombination, thereby executing the optimization.

19. A computer readable recording medium with a program stored for making a computer execute a component mounting order optimization method in a component mounting operation in which a component is held from one component supply part (103a) disposed at a component holding position (171) among a plurality of component supply parts (103a) arranged in parallel and movable for supplying components, is transferred to a component mounting position (172), and is mounted to a mounting point (173) on a circuit board (2) disposed at the component mounting position by moving in X-axis and Y-axis directions,

the recording medium having the program for executing:

a procedure of representing the mounting point (173) in a three dimensional space which is given that a Z-number showing a location of each component supply part (103a) is expressed by a Z-axis and a plane of the circuit board (2) is expressed by the X and Y-axes; and

a procedure of determining an arrangement of the component supply parts (103a) and a component mounting order on the circuit board (2) so that a component mounting

path connecting the mounting points (173) in the three dimensional space becomes the shortest.

20. The computer readable recording medium according to Claim 19, wherein the procedure of determination has:
a procedure of optimizing the arrangement of the component supply parts (103a) with position information of the mounting points (173) taken into account; and then
a procedure of optimizing the component mounting path in the three dimensional space so that the mounting path becomes the shortest under the optimized arrangement of the component supply parts (103a).

21. The computer readable recording medium according to Claim 20, further comprising:
after the optimization of the component mounting path, a procedure of rearranging the component supply parts (103a);
a procedure of optimizing the component mounting path again under the rearrangement of the component supply parts (103a); and a procedure of selecting a component mounting path having a shorter mounting path length through comparison between before and after the rearrangement of the component supply parts (103a).

22. The recording medium according to Claim 20, wherein the optimizing procedure for the arrangement of the component supply parts (103a) includes a procedure of temporarily arranging the component supply parts (103a) and a procedure of correcting the temporary arrangement before the optimizing procedure for the component mounting path.

23. The recording medium according to Claim 22, wherein the temporary arrangement procedure in the optimizing procedure for the arrangement of the component supply parts (103a) includes a procedure of obtaining a product of variances ($\sigma 1$, $\sigma 2$) of each of X and Y-coordinate values and Z-values showing locations of the component supply parts (103a) while the Z-value is changed in terms of the mounting points (173) of the circuit board (2), and a procedure of obtaining the arrangement of the component supply parts (103a) which makes the variance product ($\sigma 1$, $\sigma 2$) smaller.

24. The recording medium according to Claim 23, wherein the arrangement procedure for making the variance product ($\sigma 1$, $\sigma 2$) smaller includes:
a first procedure of obtaining a first variance product for a first arrangement of the component supply parts (103a);

a second procedure of obtaining a second variance product for a second arrangement different from the first arrangement;

a third procedure of comparing the first variance product and the second variance product with each other and setting the smaller one as a new first variance product; and

a procedure of obtaining a much smaller new first variance product by repeating the second procedure and the third procedure subsequently.

25. The recording medium according to Claim 22, wherein the correcting procedure for the temporary arrangement in optimizing the arrangement of the component supply parts (103a) includes, after the component supply parts (103a) are temporarily arranged by obtaining the smaller variance product, a procedure of changing the location of a second component supply part (103a-2) on a basis of a distance between a reference mounting position (178) on the circuit board (2) where the component supplied from a first component supply part (103a-1) adjacent to the component holding position is to be mounted and an object mounting position (179) on the circuit board (2) where the component supplied from the second component supply part (103a-2) other than the first component supply part (103a-1) is to be mounted, thereby further optimizing the arrangement of the component supply parts (103a).

26. The recording medium according to Claim 25, wherein the procedure of changing the location of the second component supply part (103a-2) includes a procedure of obtaining each of the distances while the second component supply part (103a-2) is sequentially changed, and arranging the second component supply part (103a-2) which makes the distance shortest to be adjacent to the first component supply part (103a-1).

27. The recording medium according to Claim 20, wherein the optimizing procedure for the component mounting path includes a procedure of selecting two among mounting paths for connecting two mounting points (173), recombining the two mounting paths, and selecting the path having a shorter mounting path length through comparison between before and after the recombination, thereby executing the optimization.

28. A component mounting apparatus comprising.

a component supply unit (103) having a plurality of supply parts (103a) arranged in parallel for supplying components, for supplying components from one of the supply parts positioned to a component holding position (171);

a component shift device (105) having a component holder (105b), for transferring the component holder between the component holding position (171) and a component

mounting position (172), holding components (175) supplied from the supply parts by the component holders and mounting the components to mounting points (173) on a circuit board (2) at the component mounting position;

an orthogonal table (109) for holding the circuit board (2) and moving the circuit board (2) in X and Y-axes directions, thereby locating the mounting points (173) to the component mounting position; and

a controller (180) for optimizing a mounting operation of the components to the circuit board (2) from the supply parts, which includes an arrangement optimizing part (181) for representing the mounting point (173) in a three dimensional space which is given that a Z-number showing a location of each component supply part (103a) is expressed by a Z-axis and a plane of the circuit board (2) is expressed by the X and Y-axes, and a mounting path optimizing part (182) for determining an arrangement of the component supply parts (103a) and a component mounting order on the circuit board (2) so that a component mounting path connecting the mounting points (173) in the three dimensional space becomes the shortest.

29. The component mounting apparatus according to Claim 28, wherein the arrangement optimizing part carries out optimization of the arrangement of the component supply parts (103a) with position information of the mounting points (173) taken into account, and the mounting path optimizing part carries out optimization of the component mounting path in the three dimensional space so that the mounting path becomes the shortest under the optimized arrangement of the component supply parts (103a).

30. The component mounting apparatus according to Claim 29, wherein the mounting path optimizing part further carries out rearrangement of the component supply parts (103a) after the optimization of the component mounting path, optimization of the component mounting path again under the rearrangement of the component supply parts (103a), and selection of a component mounting path having a shorter mounting path length through comparison between before and after the rearrangement of the component supply parts (103a).

31. The component mounting apparatus according to Claim 28, wherein the arrangement optimizing part obtains a product of three variances of each of X and Y-coordinate values and Z-values showing locations of the supply parts while the Z-value is changed in terms of the mounting points (173) on the circuit board (2), and obtains the arrangement of the component supply parts (103a) which makes the variance product ($\sigma 1$, $\sigma 2$) smaller.

32. The component mounting apparatus according to Claim 31, wherein the arrangement optimizing part obtains the arrangement which makes the variance product ($\sigma 1$, $\sigma 2$) smaller by obtaining a first variance product for a first arrangement of the supply parts, obtaining a second variance product for a second arrangement different from the first arrangement, comparing the first variance product and the second variance product with each other to set the smaller one as a new first variance product, and obtaining a much smaller variance product as a new first variance product by repeating the comparison.

33. The component mounting apparatus according to Claim 31, wherein the arrangement optimizing part further optimizes the arrangement of the supply parts, after optimizing the arrangement of the supply parts by obtaining the smaller variance product, caused by changing a location of a second supply part (103a-2) on a basis of a distance between a reference mounting position (178) where the component supplied from a first supply part (103a-1) adjacent to the component holding position is to be mounted and an object mounting position (179) where the component supplied from the second supply part (103a-2) other than the first supply part (103a-1) is to be mounted.

34. The component mounting apparatus according to Claim 33, wherein for changing the location of the second supply part (103a-2), the distance is obtained while the second supply part (103a-2) is sequentially changed and the second supply part (103a-2) which makes the distance shortest is arranged adjacent to the first supply part (103a-1).

35. The component mounting apparatus according to Claim 28, wherein the mounting path optimizing part optimizes by selecting two among mounting paths for connecting two mounting points (173), recombining the two mounting paths, and selecting the path having a shorter mounting path length through comparison between before and after the recombination.

36. The component mounting apparatus according to Claim 35, wherein the mounting path optimizing part changes a mounting order of mounting points (173) which constitute a new mounting path after the recombination of mounting paths, in accordance with the new mounting path.